Identifying curriculum factors that facilitate lifelong learning in alumni career trajectories: Stage 2 of a sequential mixed-methods study

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Abstract

This research paper presents results from the second stage of a sequential mixed-methods study exploring the impact of undergraduate curriculum on lifelong learning orientations in the context of varying alumni career trajectories. Lifelong learning mindsets and skillsets are essential for graduates of engineering programs as they grapple with an array of sociotechnical challenges and unpredictable career paths.

Previously, we used interview findings, in combination with a literature review, to develop a conceptual framework and alumni survey that address several related constructs: career trajectories, workplace learning orientations and undergraduate learning orientations, curricular and extra-curricular experiences and perceptions, and pre-university characteristics. The survey was designed to address the following descriptive and explanatory research questions within the larger study:
RQ1) How can we characterize individuals' lifelong learning motivations and strategies before university, during university, and in their current workplace context?
RQ2) What changes in lifelong learning orientations can we observe between these time-periods?
RQ3) What influences do curricular experience factors have on lifelong learning orientations?

We recruited alumni who graduated between 1991 and 2020 from two engineering departments at our institution to participate in the survey and received 279 complete responses. We found significant differences in lifelong learning motivations between the undergraduate and workplace stages (increases in the importance of one's interest in the context or activities and in achieving success; a decrease in the influence of avoiding failure). We also found correlations between undergraduate and workplace learning approaches in terms of tendencies towards memorizing information, understanding through making connections, or taking more proactive approaches.

1.0 Introduction

This research paper explores engineering graduates' career trajectories and lifelong learning orientations throughout their education and careers to begin to identify how different situated learning experiences can influence lifelong learning orientations (attitudes and values related to lifelong learning). There is wide awareness that the engineering profession has a role to play in addressing global socio-technical problems such as climate change and digital misinformation [1]. At the same time, rapid technological change and other shifts in the labour system mean that engineers' workplace responsibilities and career paths are prone to uncertainty and precarity [2]. As will be discussed, lifelong learning competencies can enable individuals to navigate these changes and challenges in their individual career trajectories and to make innovative technological contributions. As part of a curriculum realignment project in the Division of Engineering Science [3], [4], we are investigating how undergraduate curricular experiences can influence lifelong learning orientations. This paper focuses on the experiences of alumni from two engineering departments at the University of Toronto (Canada) to clarify what graduates' career trajectories look like and to identify changes in a particular dimension of lifelong learning – outcome motivation – between undergraduate and career settings.

This paper begins with a background literature review on lifelong learning and engineering students' careers and an overview of our previous work to develop a conceptual framework that integrates literature and findings from preliminary alumni interviews. It then explains the survey methods used to collect the data presented and analysed here, ending with a discussion of results. Understanding factors that influence lifelong learning can inform undergraduate program design to deliberately develop this competency in students, and can support professional organizations and employers in facilitating professional development and career transitions (e.g. [5])

1.1 Literature Review

In Canada, accredited undergraduate programs are the first step to professional licensure as an engineer [6], although many program graduates go on to non-engineering careers [7], [8]. Lifelong learning is one of twelve graduate attributes that engineering programs are expected to develop in students and there are still many questions about how this should be approached. We seek to gain a better understanding of what alumni workplace contexts imply for lifelong learning and how lifelong learning can support graduates' careers and broader development, starting with this literature review.

1.1.1 Conceptions of Lifelong Learning

Engineering graduate attributes have been criticized for their brief and generic definitions [9]; the Canadian Engineering Accreditation Board defines lifelong learning as a student or graduate's "ability to identify and to address their own educational needs in a changing world in ways sufficient to maintain their competence and to allow them to contribute to the advancement of knowledge" [10]. At the same time, when looking to the broader literature to understand conceptualisations of lifelong learning, there is a tendency for the concept to lose meaning and precision as it is identified in many different contexts and for many different purposes [11].

There is an implicit conflict between regional economic desires for lifelong learning that produces a productive workforce and broader conceptions supporting personal development, social inclusiveness, and democratic participation [12]. With the ongoing changes to the nature of work that arise from disruptive technological developments, education systems and policies need to promote some combination of job-specific competencies and capacities that enable further learning (including preparation for "adaptability, transition, creativity, problem-solving, and decision-making"); these are often associated with liberal education [12] which differs from the math, science, engineering science, and design focus of engineering curriculum. Education systems and cultural values sometimes prohibit lifelong learning 'habits of mind' as the value of learning or doing responsible, informed work is de-emphasized in relation to short-term goals of obtaining credentials and being associated with institutional prestige [12]. Broadening conceptions beyond formal learning in educational institutions or professional development programming, “lifewide learning” recognizes the multiple overlapping spaces and contexts where learning occurs [13], [14]. Lifewide conceptions of lifelong learning account for non-economic strands such as family life, social life, and recreational activities, and provide an integrated framework with a basis in education [12]. The lifewide aspect of lifelong learning is important as it captures the way individuals learn in response to situations across different spaces in their lives and how these learnings holistically support personal development [14].

Considering lifewide learning as an phenomenon unique to each person, the concept of learning careers [15] takes a maximalist view of lifelong learning as transformations in any learning “strand” of life (personal, professional, etc.) and focuses on individuals’ dispositions towards learning and how they are enacted in social practices and shaped by social contexts. It is grounded in theories from education and sociology, incorporating situated learning theory, symbolic interactionism, and Bourdieu’s habitus to balance stances of individual agency and structural determinism in learning [15]. The evolving nature of lifelong learning dispositions will be central to our work.

1.1.2 Lifelong Learning and Engineering Education

Engineering education researchers, education researchers, and sociologists have looked at connections between engineering education, engineering work, and lifelong learning from different perspectives. Researchers frequently uncover, define, and explain gaps between engineering education and practice, including gaps in preparation for lifelong learning. We summarize several central studies here.

Looking at gaps between engineering education and practice, Brunhaver et al. (2018) interviewed early career engineers in the United States and determined that “engineering work is much more variable, complex, and social than most engineering curricula convey” requiring extensive on-the-job learning in response to project needs and education gaps [16]. After graduation, many alumni discover the importance of independently managing information and communicating with people from “different walks of life” and need to develop skills that enable this socially-driven, cross-disciplinary work; 16/29 participants considered their work to go beyond their discipline of study [16]. There is also an important aspect of learning about the workplace or organizational context; it appears that early career engineers struggle to make connections between what they have learned about current or previous workplaces to support their work activities or broader development and career success [16]. Finally, the authors note that with more career experience, engineers’ responsibilities change and they “move into less technical roles with broader scope” requiring different skillsets but at the same time, the authors express a narrow definition of lifelong learning – “engineering graduates must be able to direct their own learning when they recognize they do not know something” [16]. While this paper focuses on how engineering education can better meet industry needs to close some of these gaps, the authors do acknowledge that industry could better support early career engineers in the transition and could improve role- and qualification-alignment to reduce underemployment issues.

Also investigating the alignment between engineering education and practice, Passow & Passow (2017) sought to understand the nature of engineering work in relation to undergraduate education practices and accreditation outcomes [17]. They noted that "engineering work is typically project based; therefore, engineering tasks and the required competencies are tied to the life-cycle of a product, process, or system" [17]. This implies the situated nature of both practice and on-the-job learning experiences. A systematic review of importance ratings of different competencies suggests that prioritization does not change with graduation year or years of experience in engineering [17] i.e. at the aggregate level, the priority of the lifelong learning competency does not increase or decrease with experience relative to other core and professional competencies. At the same time, graduate attribute definitions of lifelong learning don't explicitly capture aspects essential to engineering practice including taking initiative, thinking creatively, making decisions or exercising judgement, and integrating and coordinating other competencies [17]. The authors identify the importance of team- and project-based educational activities that emulate workplace experiences to develop these competencies and lifelong learning orientations [17].

From a sociology of professions perspective Adams & Sawchuk (2021) sought to understand how professional engineering knowledge is developed and used given changes in the profession [18]. 51.2% of engineers responded that they possessed more or much more core professional knowledge than was needed but also needed to address gaps in their broader professional or complementary competencies [18]; this may be an indication of how engineers compartmentalize core technical knowledge from other forms of professional and organizational knowledge that enable their work. These complementary capabilities have always been required to some extent in engineering practice, and are particularly important in ensuring the technological developments they participate in serve larger society as well as employers and clients [19]. While issues related to growing workloads and lack of on-the-job training and support are a concern, the scope of professional knowledge required is not unexpected given the socio-technical nature of engineering work [20]; it is not entirely clear to what extent the perspectives captured in this work could be symptomatic of a well-documented engineering culture that deprioritizes the social aspects of engineering versus a response to organizational and managerial pressures which engineering has always been closely tied to [21]. Regardless, if engineering education can develop the skills and attitudes supportive of lifewide and lifelong learning, program graduates can potentially be better prepared to learn to navigate these challenges and regain their power and autonomy in the professional workplace.

Along these lines, researchers have clarified the learning challenges posed when students graduate and transition to the workplace. While traditional engineering jobs do center around engineering problems, many significant learning events are prompted by the change in context and a graduate's need to understand how to calibrate their complementary skills (e.g. communication, project management) to the particular workplace context [22]. Developing graduates who are primed to apply their lifelong learning abilities to these interconnected social, cultural, and technical challenges appears essential for successful transitions and for undergraduate problems to assert their long-term value.

Thus, how can engineering programs foster these lifelong learning benefits? Focusing on interventions for self-regulated learning and metacognition sub-dimensions of lifelong learning, a systematic scoping review found 13 studies documenting self-regulated learning interventions &/or their efficacy in engineering education contexts [23]. The authors noted that the majority of these studies were not well-grounded in theory, and more extensive research is required to clarify how instruction can benefit these dimensions of lifelong learning [23]. While this review did not provide any relevant insights, some standalone studies do.

Evaluating program-wide teaching strategies expected to better prepare engineers for lifelong learning in these career contexts, Marra et al. (2017) interviewed 15 recent graduates (3-4 years after graduation) of an undergraduate engineering program in the United States to investigate how the program's teaching and learning of metacognitive skills through reflective activities translated to lifelong learning in the workplace context [24]. They found that in connection to the course projects that emulated the self-directed learning common in workplace environments, being comfortable with uncertainty and confident and resilient in the face of overwhelming challenges were important dispositions that enabled lifelong learning in the workplace after graduation [24]. The researchers also distinguished between alumni who saw metacognition as having a narrower role specifically for engineering problem solving activities, and those who used it in support of professional skills such as communication and other interpersonal competencies [24]. The latter is important for the challenges faced by the engineering profession discussed earlier, as well as for engineering alumni who pursue alternate careers outside of engineering.

Isolating the impacts of capstone design experiences on lifelong learning in workplace transitions, researchers studied alumni from four different institutions to understand their weekly work activities and challenges that prompted learning during the initial three months in the workplace [25]. Echoing the studies above, they found that challenges were often connected to the need for self-directed learning that was not present in the undergraduate context, as well as interpersonal interactions with a more diverse collection of colleagues [25]. While capstone experiences could not fully prepare individuals for these challenges, their tendency to replicate many aspects of the workplace provided moderate preparation

Looking to the Canadian context where lifelong learning is still recognized as a graduate attribute for accreditation, there has been some engineering education research into teaching, learning, and assessing lifelong learning within undergraduate programs. We reviewed graduate attribute definitions from 16 Canadian universities and found that lifelong learning was most often conceptualized in terms of self-directed learning skills with few institutions considering students' developing dispositions, orientations, or attitudes towards learning [26]. We found various cases where individual instructors documented pedagogical approaches towards teaching lifelong learning in a particular course, or a small collection of courses, but rarely do lifelong learning outcomes influence program-level curricular design [26].

One exception to this is a study into the learning experiences and lifelong learning aptitudes of third- and fourth-year students in one Canadian engineering program [27]. The students who chose to participate in focus groups about their undergraduate educational experiences expressed strong aptitudes for lifelong learning but also demonstrated some differences between third- and fourth-year groups; fourth-year students demonstrated "a more reflective quality" and recognized the need to engage in lifelong learning (i.e. a disposition or orientation towards the value of learning), while third-year students were more focused on their learning skills or abilities as they applied to the remainder of their formal education [27]. This may be evident of greater personal development due to maturity and/or experience, an awareness of their formal education years coming to an end, or other factors.

These findings suggest that programs in Canada are addressing a limited definition of lifelong learning that might not fully support student competency after graduation and are not considering how a program as an integrated whole may impact the lifelong learning competency of students. Accordingly, there is a need for more Canadian research that characterizes the gap between undergraduate program experiences and their impacts on lifelong learning throughout careers. Additionally, the impacts of undergraduate programs for lifelong learning dispositions (or orientations) are not well-understood in the broader engineering education literature.

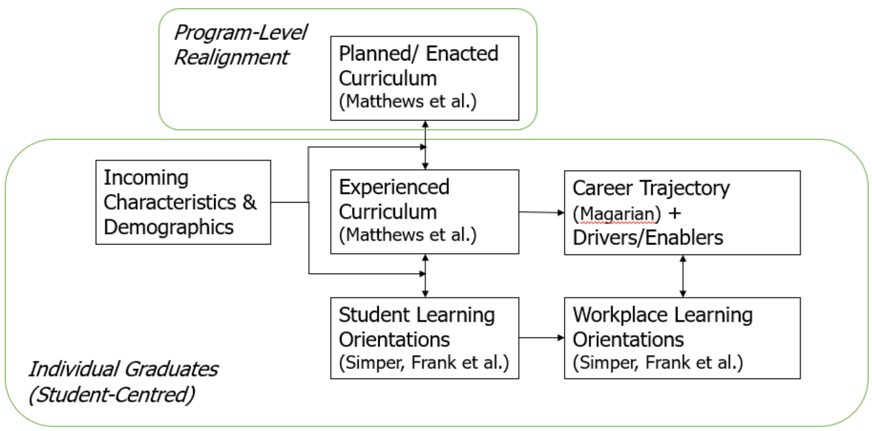
1.2 Conceptual Framework

Recognizing these gaps, our research began with the development of a conceptual framework that adequately captures the breadth of lifelong learning while focusing on curricular experiences and career trajectories. Lifelong learning by definition spans individuals' lifetimes; however, most research looks at particular time periods rather than their cumulative connections. We needed a framework that allowed us to look at the impact of undergraduate curriculum on long-term lifelong learning outcomes, particularly orientations or dispositions in addition to skills. Our framework is built upon a combination of literature sources and the exploratory interview phase of our research.

As part of the larger curriculum realignment project, we conducted exploratory semi-structured interviews with 24 alumni who graduated between 1991 and 2020 [28]. We analyzed the data to identify themes related to career trajectories, lifelong learning, and workplace learning motivations and strategies and integrated these with existing concepts and relationships from lifelong learning, education, and college/university impact literature to develop a conceptual framework (Figure 1) that addresses lifelong learning across and between undergraduate engineering education and career trajectories.

While there are numerous formulations of lifelong learning and its dimensions, we incorporated the Transferable Learning Orientations model [29] which has been developed in the Canadian engineering education context and is based on the Motivated Strategies for Learning Questionnaire [30], [31] with sufficient emphasis on attitudinal dimensions of lifelong learning. We consider how immediate and long-term learner outcomes are influenced by curricular experiences and the curriculum planned and enacted at higher levels (Planned-Enacted-Experienced curriculum; [32]–[34]) as well as individuals' incoming characteristics and demographics [35]. Finally, we conceptualize career trajectories in a more abstract way that does not focus on industry sectors but rather relatedness to engineering and extent of transitions, including a recent typology of occupation outcomes [2]. Focusing on two distinct contexts, we differentiate between Transferable Learning Orientations in the undergraduate context (Student Learning Orientations) and the workplace (Workplace Learning Orientations).

Figure 1: Conceptual Framework



1.3 Research Approach

The larger work is an exploratory sequential mixed-methods study in line with a pragmatic worldview. This paper addresses three research questions within the larger study:
RQ1) How can we characterize individuals' lifelong learning motivations and strategies before university, during university, and in their current workplace context?
RQ2) What changes in lifelong learning orientations can we observe between these time-periods?
RQ3) What influences do curricular experience factors have on lifelong learning orientations?
We expect that this focus could provide interesting insights for engineering education community members who look at the impacts of undergraduate programs or wish to consider program-level adjustments as these findings begin to articulate the nuanced relationships between program-wide curricular experiences, career trajectories, and lifelong learning of alumni.

2.0 Survey Methods

This section briefly describes the survey methods used in this study. Much of the approach taken followed best practices for surveys in social research [36] while specific survey questions were adapted from literature sources mapped in the conceptual framework. A separate paper (forthcoming) describes and critiques the survey in more depth.

2.1 Survey Development and Administration

As discussed above, the survey was developed to address concepts and constructs in the conceptual framework. Questions were developed based on a combination of existing theories and instruments and interview findings. Because this is part of a pragmatic mixed-methods study seeking exploratory quantitative relationships to interrogate the "why" of in subsequent narrative interviews, we have not performed extensive psychometric analyses. We did follow best practices in developing valid and reliable questions with expert feedback and cognitive interviewing. Draft versions of the survey were revised based on feedback from curriculum experts within the programs as well as an educational survey expert; guidance focused on overall design, construct validity, and clarity [37]. Four alumni participated in think-aloud cognitive interviews and this information was used to ensure the survey questions would be interpreted as intended, that we could be confident in the quality of responses, and that survey length would promote participation and completion [38], [39]. The complete survey is composed of 45 questions including 10 matrix questions, was implemented online using REDCap software for data security, and was shared with alumni via emails from alumni outreach offices. The survey was open October 6 to November 21, 2021.

2.2 Population and Sampling

The desired population of respondents was alumni of undergraduate programs in the Division of Engineering Science and the Department of Mechanical & Industrial Engineering between graduation years of 1991 and 2020. This timespan was intended to capture the experience of recent graduates and well as those with more extensive career experience. Participants were recruited via email, so the sample was a convenience sample of those who received the email (i.e. the correct email was in the database) and chose to participate. We recognize that there may be bias in the sample based on these considerations, although a quality control question regarding overall sentiment towards the programs did not indicate an overly "rosy" view [40] ("The program met my overall expectations" median response = "Neutral"). We received 279 complete responses from 5,093 emails on file – a 5.5% response rate.

3.0 Results

This paper presents results from a sub-set of survey questions focusing on the relationship between experienced curriculum and lifelong learning orientations. Other results are presented in a separate publication that contrasts alumni perspectives on lifelong learning's role in careers with accreditation definitions [41]. We begin this section by briefly describing the sample's demographic and pre-university characteristics.

3.1 Descriptive Statistics: Participant Characteristics

Table 1 displays pre-university characteristics while Table 2 displays demographic data. The tables report on the proportion of respondents represented in the majority group for each characteristic; although more detailed breakdowns will be used to explore the influences of individual factors. These values may be of interest to other institutions that wish to compare the sample to their own alumni and students, or to researchers who wish to compare the sample to engineering students and alumni across Canada.

Table 1: Pre-University Characteristics of Survey Respondents

Characteristic	**Sample**		**[Program 1] Population**	
	n	%	n	%
Citizenship as incoming student: Canadian citizen	241	86%	3130	76%
Parent/guardian in STEM: yes	164	63%	unknown	
High school STEM grades: top 10%	240	91%	unknown	
High school non-STEM grades: top 10%	168	63%	unknown	

This information was self-reported retrospectively as part of the survey response; the high school grade reports especially could be somewhat inaccurate, although we know that grade averages for Ontario high school students entering the [faculty] from 2000-2019 are typically high (M = 89.7%). We also find that Canadian citizens may be overrepresented in our sample; between 2000 and 2019, an average of 19.7% of first year students across the [faculty] were international students.

Table 2: Demographic Characteristics of Survey Respondents

Characteristic	**Sample**		**[Program 1] Population**	
	n	%	n	%
Gender: man	167	63%	3228	78%
Person of colour: no	138	55%	unknown	
Sexual orientation: heterosexual	225	89%	unknown	
Person with a disability: no	230	91%	unknown	

Demographic questions were framed in terms of participants' current identities and characteristics at the time of the survey. It appears that men are underrepresented in the sample; from 2002-2019 the percentage of men undergraduate students in the Faculty of Applied Science & Engineering was on average 74.5%. We are working to find appropriate sources to compare the other characteristics of the sample to the population or proxy values. Age or year of birth is not reported because 40 respondents chose to withhold this information. The median graduation year of all 279 participants was 2012 meaning that respondents were slightly skewed to more recent graduates in the 1991 to 2020 timeframe, which is to be expected.

3.2 Descriptive Statistics: Participant Career Trajectories

In Table 3 we present descriptive statistics that characterize participant career trajectories in terms of career transitions, relatedness to engineering, and other relevant factors. These data are intended to serve as a source of comparison for readers so that they might consider the similarities and differences of alumni contexts.

Table 3: Career Trajectory Statistics

Survey Question [Factor]	**Results**
How many organizations have you worked at since graduating from your undergraduate program? [Transitions]	*M* = 2.76, *SD* = 1.81
How many distinct professional roles have you held since graduating from your undergraduate program? [Transitions]	*M* = 3.44, *SD* = 2.33
Have you ever made what you consider to be a major career transition? [Transitions]	No: 153 (55%) Yes: 126 (45%)
How closely related is this role to your undergraduate field of study? [Relatedness]	Closely related: 105 (38%) Somewhat related: 122 (44%) Not at all related: 50 (18%)
Proximity to engineering (modified from Magarian & Seering, 2021). [Relatedness]	Engineering occupations: 129 (47%) Engineering-adjacent occupations: 75 (27%) Other occupations employing STEM-related knowledge or skills: 55 (20%) Other non-STEM occupations: 18 (6%)
Do you currently have a valid professional engineer designation or license (e.g. Ontario P.Eng)? [Relatedness]	Yes: 63 (23%) No, but I am planning to obtain one in the near future: 55 (20%) No, but I did in the past (i.e. it has expired or lapsed): 4 (1%) No, I never have and I am not planning to obtain one in the near future: 157 (56%)
Have you ever founded a start-up or venture company? [Entrepreneurship]	Yes: 36 (13%) No: 243 (87%)
Highest level of education (may be in engineering or other fields). [Further education]	Bachelor's degree: 102 (37%) Other skilled trades (in addition to engineering bachelor's degree): 6 (2%) Master's degree: 113 (41%) Doctoral degree (PhD): 43 (15%) Another professional degree (e.g. medicine, law): 15 (5%)

In terms of career transitions, we find it notable that 45% of respondents report making a major career transition and as part of our data mixing we plan to analyse an open response that followed this question to understand how alumni conceive of “major” career transitions. For the questions regarding organization and role transitions, respondents were instructed to exclude any roles performed during graduate education such as teaching assistantships or research assistantships.

In terms of relatedness to engineering, multiple measures illustrate the tendency of the responding graduates to move away from their disciplines of study, and to some extent, engineering careers altogether, after graduation.

3.3 RQ1: Lifelong Learning Orientations at Different Stages of the Career Trajectory

We analysed participants’ ratings of lifelong learning motivation and strategy dimensions to address RQ1 (How can we characterize individuals’ lifelong learning motivations and strategies before university, during university, and in their current workplace context?) and RQ2 (What changes in lifelong learning orientations can we observe between these time-periods?). These questions draw on both retrospective and present perspectives in order to make a comparison.

The motivation dimensions data came from a series of Likert-type questions influenced by the Transferable Learning Orientations tool [29] and the Motivated Strategies for Learning Questionnaire [30], [31]. The specific questions and findings are presented in Table 4 with frequency and percentage reported for each rating level and a summary statistic in the median value across the sample. Data from the first set of questions reflect lifelong learning motivations prior to entering the undergraduate program (self-reported retrospectively giving the timing of the survey, and denoted as “Incoming” in Table 4), data from the second set reflect respondents’ learning motivations while a student in the undergraduate program (denoted as “Undergrad” in Table 4), while data from the third set of questions reflect lifelong learning motivations in alums’ current career contexts (“Career” in Table 4).

Table 4: Lifelong Learning Motivations

Motivation	Success			Interest			External*		
	Incoming	**Undergrad**	**Career**	**Incoming**	**Undergrad**	**Career**	**Incoming**	**Undergrad**	**Career**
0 V. unimportant	8 (%)	7 (2.5%%)	5 (1.8%)	6 (%)	6 (2.2%)	4 (1.4%)	19 (%)	21 (7.6%)	32 (11.6%)
1	16 (%)	16 (5.7%)	6 (2.2%)	8 (%)	10 (3.6%)	3 (1.1%)	59 (%)	17 (6.1%)	42 (15.2%)
2 Neutral	41 (%)	26 (9.3%)	17 (6.1%)	11 (%)	21 (7.6%)	20 (7.2%)	66 (%)	47 (17.0%)	67 (24.2%)
3	109 (%)	97 (34.8%)	104 (37.4%)	69 (%)	112 (40.4%)	90 (32.5%)	59 (%)	108 (39.0%)	85 (30.1%)
4 V. important	102 (%)	133 (47.7%)	146 (52.5%)	185 (%)	128 (46.2%)	160 (57.8%)	76 (%)	84 (30.3%)	51 (18.4%)
Median rating (/4)	3	3	4	4	3	4	2	3	2

- **Incoming:** How important were each of the following in your choice of undergraduate program?
  - Getting a good job [**success**]
  - Personal **interest** in the subject matter
  - **External** pressure to obtain a STEM degree
- **Undergrad:** How important were each of the following for motivating you to learn course content during your time in the program?
  - Achieving academic **success** e.g. good grades
  - Personal **interest** in the subject matter
  - Avoiding **being seen as** a failure [external]
- **Career:** How important are each of the following for motivating you to learn in your current professional role?
  - Achieving workplace **success**
  - Personal **interest** in the subject matter or activities
  - Avoiding **being seen as** a failure [external]

Median ratings for dimensions of achieving success and interest in the subjects/activities appear to increase from the undergraduate setting to the career setting, although respondents on the aggregate reported a decrease in interest in the subjects/activities from before to during the undergraduate experience. Median ratings for external motivators like "avoiding being seen as a failure" increase from pre-program to during undergraduate education, then decrease from the undergraduate setting to the career setting. We will need to assess the significance of these differences. In future work we also plan to compare responses across graduation years (given the thirty-year timespan of graduates), other demographic factors, and career trajectory characteristics.

The strategies or approaches dimension data was also informed by the Transferable Learning Orientations tool [29]. It entailed a series of ranking questions that asked:

- How did you typically study when you were an undergraduate student? Please rank the following approaches to indicate your overall tendency. The approach you used the most should be ranked #1 and the approach you used the least should be ranked #4.
    - I memorized key information like definitions, formulae, and algorithms
    - I worked through problems to remember solution methods
    - I worked through problems to gain understanding of solution methods
    - I made meaningful connections to underlying concepts or theory to gain deeper understanding
- How do you typically approach work tasks that are outside of your existing knowledge base or skill set? Please rank the following approaches to indicate your overall tendency. The approach you use the most should be ranked #1 and the approach you use the least should be ranked #4.
    - I memorize key information that pertains to a specific task
    - I relate task-related information to what I already know
    - I make meaningful connections to increase my overall understanding of a subject
    - I tend to seek out knowledge and skills that I believe are important beyond any immediate task

We used mixed methods to categorize these responses into a single ordinal variable for the undergraduate time period and a single ordinal variable for the current workplace context; approaches that go beyond memorization to making connections or seeking information more broadly are considered more learning-oriented. In addition to considering the respondents' first- and second- rankings, we reviewed an open-response question that clarified their interpretation of the approaches. Most responses were categorized based on the first-choice ranking unless further data indicated otherwise; see Table 5.

Table 5: Lifelong Learning Approaches

Learning Approach (Undergrad)	**count**	**Learning Approach (Career)**	**count**
I memorized key information like definitions, formulae, and algorithms	44 (21.2%)	I memorize key information that pertains to a specific task	22 (7.9%)
I worked through problems to remember solution methods	46 (22.1%)		

I worked through problems to gain understanding of solution methods	118 (56.7%)	I relate task-related information to what I already know OR I make meaningful connections to increase my overall understanding of a subject	168 (60.6%)
		I tend to seek out knowledge and skills that I believe are important beyond any immediate task	87 (31.4%)

3.4 RQ2: Changing Learning Orientations

We created new variables (Table 6) to investigate how individual respondents' learning motivations and strategies changed with context (before, during, and after the undergraduate program i.e. incoming, during the program, and in the workplace). These ordinal variables, determined based on the direction of difference between participants' self-reported ratings for two consecutive time phases (undergraduate and workplace) indicate whether motivations "increased" and whether strategies evolved towards more learning-oriented approaches versus decreasing or remaining equivalent. While some individuals demonstrated a larger increase or decrease, we collapsed the different magnitudes into these three general buckets given individual interpretations of the response scales [36].

Table 6: Change in Self-Reported Learning Orientation from Undergraduate to Workplace Context

	Approach	**Motivation - Success**	**Motivation - Interest**	**Motivation – External***
Decrease	13 (4.7%)	65 (23.4%)	36 (13.1%)	40 (14.5%)
No change	176 (63.8%)	119 (42.8%)	163 (59.3%)	118 (42.9%)
Increase	87 (31.5%)	94 (33.8%)	76 (27.6%)	117 (42.5%)

These data indicate that while the majority of alumni did not report changes in their approaches and motivations between the undergraduate and career context, a large minority did, and their experiences are of particular interest. The purpose of creating these new variables, versus testing for differences across the repeated group measures, was to support our third research question addressing the characteristics and curricular experiences of individuals who did self-report changes in their motivations and strategies at the different time periods.

3.5 RQ3: Influential Curricular Factors

The variance in individual responses given the nuance of the questions prohibited us from using simple regression methods of analysing relationships more comprehensively, although we plan to pursue this further. We explored curriculum and individual factors to identify variables that have a significant influence on changing lifelong learning orientations including motivations related to interest, success, and avoiding failure (external). Given the ordinal data, we used non-parametric techniques (Kruskal Wallis test) unless otherwise noted. See Table 7.

Table 7: Curricular Factors that Influence Changes in Learning Orientations

Curricular Factor	**department (df = 1)**		**engineering major (df = 5)**		**program expectations (df = 4)**	
Learning Orientation Dimension	Kruskal-Wallis chi-sq	p-value	Kruskal-Wallis chi-sq	p-value	Kruskal-Wallis chi-sq	p-value
motiv-interest	2.2351	0.1349	2.3962	0.792	5.2322	0.2643
motiv-success	11.459	0.0007116*	31.117	8.88e-06*	10.904	0.02766*
motiv-external	0.56462	0.4524	6.8995	0.2282	3.7669	0.4385
approach	0.37206	0.5419	6.2801	0.2799	13.484	0.009136*
Curricular Factor	**curriculum breadth (df = 4)**		**theoretical content (df = 4)**		**practical content (df = 4)**	
motiv-interest	10.445	0.03356*	9.5924	0.04788*	6.8177	0.1458
motiv-success	3.7153	0.4459	8.4956	0.07502	13.911	0.007583*
motiv-external(-)	1.6258	0.8042	1.4013	0.844	1.9662	0.742
approach	1.8778	0.7582	3.5761	0.4664	3.909	0.4185

Factors that appear to have a significant effect on changes in one or more lifelong learning dimension include one's home department or engineering major, level of satisfaction with the program relative to expectations, curriculum breadth, theoretical content, and practical content. Respondents that considered curricular breadth and/or theory to be less beneficial or impactful tended to demonstrate an increase in interest-driven motivation from the undergraduate context to the workplace. These are preliminary results and we intend to take this analysis further in the near future.

4.0 Discussion

In our data, we see that approximately one third of respondents reported "increases" in lifelong learning motivations and strategies between the undergraduate and workplace context. This suggests that aspects of the undergraduate experience or environment do not promote the learning dispositions that programs should presumably be aiming for.

This survey also reiterates the complexity of lifelong learning as a construct and highlights the challenge of distinguishing the impact that the overall formal curriculum may have in shaping lifelong learning orientations after graduation. While we have characterized the alumni participants and their career paths that may shape some of the individual differences in results, we can also identify unique program contexts that may have an influence. We saw differences in learning orientation changes that may be a result of the program differences; changes in lifelong learning motivations relating to subject or content are associated with perceptions of curricular breadth and theoretical content, while changes in lifelong learning motivations relating to success are associated with perceptions of practical content. The nature of these associations has not yet been characterized.

The University of Toronto is a research-intensive university and one of the two units (Engineering Science) takes a first principles approach to teaching engineering fundamentals in a multidisciplinary context before students select a major in third year [3]; the program has a history of having many alumni attend graduate school and a minority move to other professional fields. The other unit (Mechanical & Industrial Engineering) includes both mechanical engineering students (who may proceed along more traditional engineering pathways) and industrial engineering students navigating a more modern and varied field ranging from manufacturing to banking. Our participants reported strong performance in their high school grades and a large number of graduate degrees which may not be representative of all engineering graduates. Other universities that see parallels to their context may consider how their curricular breadth and approaches to teaching theoretical or first principles content could have an influence on future graduates' lifelong learning orientations, or consider the broader implications of what motivates different people to learn in the educational versus workplace environment [42].

In addition to the work discussed in the introduction, we recognize other works that provide insights and connection to our findings. In the Ontario context, there is evidence that engineering workplaces are providing less support for learning than they have in the past, prompting individuals to seek learning opportunities in their own time and to learn at a surface level to achieve specific work tasks [43]. Looking across the responses by graduation year may yield patterns that come as a consequence of these workplace changes, or that may be associated with other changes that have occurred in engineering programs and/or the workplace over time. Prior work has investigated lifelong learning's significance for university-to-workplace transitions [44] including engineering students' transitions [9]. Another work has focused on the consequences of online learning spaces for engineers' lifelong learning and careers [13]; due to survey length considerations, we did not ask respondents to report on their work setting or modes of interaction used for learning, collaboration, and other workplace activities.

5.0 Conclusion

We find that there is a tendency for alumni to move away from their undergraduate engineering disciplines and in some cases leave the profession altogether. We see an increase in ratings of the importance of content/activity interest and achieving success as sources of lifelong learning motivation in current workplace roles compared to the undergraduate context, while we see a decrease in the importance of avoiding failure as a learning motivator. Alumni from different departments demonstrated different changes in their lifelong learning motivation in relation to success, while alumni who expressed different perceptions of curricular breadth and theory demonstrated different changes in their lifelong learning motivation in relation to subject matter interest or curiosity; understanding why these differences are present could enable programs to be more deliberate in fostering certain lifelong learning characteristics in students.

As this study progresses, we intend to perform narrative interviews with a small number of survey respondents to understand lifelong learning's role in career transitions in more depth and to gain perspective on the influence of the experienced curriculum. To continue interpreting the survet data, we intend to use hierarchical regression analysis to explore the relative influences of curricular experience factors and individual and pre-university characteristics on lifelong learning orientations to address RQ4) What influences do individual and pre-university characteristics have on lifelong learning orientations? We will deliberately mix the quantitative and qualitative data [45] to generate insights into the how and why of program-level curricular experiences' roles in evolving lifelong learning orientations.

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